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Author(s): Yamaguchi, Hisato

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You can’t see it, but it’s more than 200 times stronger than steel

By Hisato Yamaguchi

The evolution of armor has been a constant struggle between protection and performance. Consider armor used to protect knights on the battlefield. Original armor designs were cumbersome and heavy, and although they worked well in keeping swords and spears at bay, the suits themselves were uncomfortably hot. The warriors inside sweated heavily during their prolonged battles. Kevlar armor used by military and police units today has evolved to protect them from bullets, but even this lighter type of armor does little to expel heat and sweat.

It was this struggle between keeping some things out (like bullets) while letting others out (like heat and perspiration) that inspired scientists at Los Alamos National Laboratory to develop a radical new type of coating dubbed “atomic armor.” Made from two-dimensional, ultrathin crystal materials, atomic armor can be applied in a skin-like layer to a particularly sensitive device without hindering its performance. So, for instance, night-vision goggles can be coated with atomic armor to protect against corrosive gases without hindering their ability to turn darkness into light.

The secret to atomic armor’s incredible performance lies in its highly innovative chemical structure, which takes advantage of crystal materials known as graphene and hexagonal boron nitride. Their atomic pattern makes the coating more than 200 times stronger than steel, while combining low permeability—meaning it is nearly impenetrable—with ultra-thinness. Even the tiniest of particles or free-moving gases simply cannot get through, yet it remains transparent, conducts electricity, and does not chemically react in any way with the surface it protects.

Amazingly, an atomic armor coating is only one atom thick. By comparison, a single sheet of paper is about 500,000 atoms thick! The unbelievable thinness of atomic armor means that it will not hinder the performance a device. With this “invisible skin,” for example, night-vision goggles can still capture and convert even tiny quantities of light from the environment into electricity, amplify that electricity, and turn the electricity back into light so a user can discern objects under the darkest and murkiest of conditions.

Atomic armor coating extends the lifetime of devices by making them much more rugged in even the most extreme environments. Thus, sensitive devices lose no performance when subjected to intense heat and radiation (inside a nuclear reactor), cold (even in outer space), or corrosive environments (inside an automobile battery or at the interfaces of a semiconductor’s integrated circuits).

Atomic armor’s protection is quite startling. For example, many modern electronic devices rely on what are called photo-emissive thin-film components. Gases that can cause no damage to us, such as oxygen and carbon dioxide, gradually erode the performance of such devices. For example, just a tiny amount of gas molecules diminishes the performance of a semiconductor photocathode used in modern high-definition television camera tubes. By coating a photocathode with atomic armor, the device retains its performance even if exposed to vast amounts of gas molecules.

The breadth of applications for atomic armor ranges from batteries and LEDs to semiconductors and solar cells. One day, it also may protect parts on aircraft, ships, and vehicles (just mix it with the paint to prevent rust) and even help in kidney dialysis (separating chemical and bacterial contaminants that erode machines and harm patients). Invisible and as tough as diamonds, nothing comes close to atomic armor.

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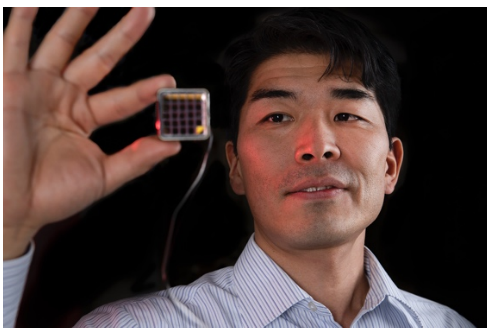
Photos and Captions

Hisato Yamaguchi studies the initial corrosion processes using surface science techniques, and synthesizes atomically thin two-dimensional protection crystals for the Finishing Manufacturing Science group at Los Alamos National Laboratory. The group is part of SIGMA Division, which develops advanced materials and components using engineering and metallurgical science.



Hisato Yamaguchi examines a material for night-vison goggles coated with atomic armor.